Flow Rates of Gavage Feedings Provided to Very Preterm Infants

Theresa Pagano, SN; Deborah Steward, PhD, RN

The Ohio State University

College of Nursing

Chapter I: Statement of Problem

Introduction

Prematurity is a significant problem in the United States. In 2005, there were over 500,000 premature births, and very premature births accounted for 84,051 of all live births (Hamilton, Martin, & Ventura, 2007). These numbers are increasing. Infants that are born this premature lack the coordination to perform the suck-swallow mechanism necessary to breast or bottle feed. Furthermore, premature infants lack the physiologic maturity of the gastrointestinal (GI) tract. Because of this, premature infants are universally fed using gavage feedings through a nasogastric (NG) or orogastric (OG) tube.

It is believed that bolus feedings are the delivery method of choice as they mimic normal feedings and create normal cyclical surges of hormones in the gut. Bolus feedings are recommended to be administered over a period of approximately twenty minutes as this also mimics a normal feeding time. Proper administration of nutrition is vital to the maturation and development of digestive, absorptive, and motor function (Riezzo, 2007).

Currently, there are no nationally published protocols or standards of procedure regulating gavage feedings in infants and very little research has been conducted in this area.

Background of Problem

Bolus feedings are traditionally delivered by gravity. Currently, gavage feeding tubes available for premature infants range in size from 3.5 French (Fr) to 10 Fr. Feedings through tubes with such narrow diameters present a problem as they often take much longer than the standard twenty minutes to infuse. Concern arises both when feedings require far more or far less time to infuse, and this is often the case with feedings that rely solely on gravity. A feeding that infuses too fast may harm the GI tract, while a feeding that infuses at too slow of a rate may not provide the proper nutrition to the infant or stimulate maturation of the GI tract.

In addition to varying tube sizes that are available for use in each individual infant, there are several other variables that must be factored in to the infusion time of a gavage feeding. The infant may require a specific feeding type, typically determined by the advanced practice health care provider. Different formulas, as well as breast milk, differ in fat, carbohydrate, protein, and calorie content. Theoretically, these differences in consistency would further affect feeding infusion time. Another factor affecting infusion time is the height at which the feeding is hung. In practice, the practitioner may choose to hang a feeding either inside or outside of the infant's isolette; the difference between these two locations is approximately five inches. A final contributing factor is the material from which the tube is made. Currently available gavage feeding tubes are made of either silicone or polyurethane. Because the size of a tube is measured by the outer diameter, and the tensile strength of polyurethane is greater than that of silicone, it can be concluded that polyurethane tubes have a larger internal diameter than silicone tubes (Salis, Eclavea, Johnson, Patel, Wong, Tennery, 2004).

Because of these issues with gravity-based feedings, many NICUs are forced to routinely rely on infusion pumps designed for intravenous use to deliver these gavage feedings. This practice is further cause for concern as these pumps were not designed to infuse enteral feedings. The potential for introducing higher pressures than can be tolerated by the infants GI tract is concerning, as well as the potential to confuse an IV pump being used for enteral feedings for an IV pump being used for IV fluids, and vice versa. Before turning to such a precarious practice, it is critical that healthcare providers have a better understanding of flow rates and when it is or is not necessary to intervene in the infusion time.

Purpose of Study

The purpose of this study is to determine actual mean flow rates of gavage feedings across several contributing variables. These variables include feeding type, tube size, tube material, and height at which the feeding is hung.

Significance of Study

Gavage feedings are intricate tasks that a NICU nurse will invariably perform several times a day. It is in fact, one of the most commonly performed procedures in the NICU. Delivery of these gavage feedings has profound implications for the maturation and development of the infant's GI tract.

There are currently no nationally published standards regarding gavage feedings and minimal research has been conducted in this area to determine best and safest feeding practices. This study will describe feeding times found in common clinical situations and lay an essential foundation for further research and eventual development of critical national standards for gavage feedings.

Hypotheses

It is expected that increased calorie and nutrient content will result in a longer feeding time. Furthermore, when feedings are hung at the higher height, it is expected that the feeding will flow faster, resulting in decreased feeding time. In addition, the use of silicone tube is expected to slow feeding time, resulting in increased feeding time. Finally, it is expected that using a smaller bore tube will result in increased feeding time. Consistent interactions between these varying clinical circumstances are anticipated. Finally, it is further anticipated that discrepancies between most variables will be significant. Once trials are performed, results will be analyzed using descriptive statistics to determine significance.

Definition of Terms

Preterm- infants born before 30 weeks gestational age

Nasogastric/Orogastric- intubation of the stomach involving nasal or oral passages

Gavage feeding- introduction of nutritive materials into the stomach by means of a tube

Bolus feeding- feeding that is introduced in a shortened period of time as opposed to a continuous drip

Enteral Feeding- intestinal feeding

Tensile Strength- the stress state leading to expansion

Chapter II: Review of the Literature

Specific Aims

For very preterm infants (those born before 30 weeks gestation), maturation of the gastrointestinal (GI) tract, including peristalsis and GI hormone production, occurs following delivery. This process occurs over several weeks and these infants are prone to signs of feeding intolerance while the GI tract matures. Bolus gavage feedings are important to include in the infant's care as they stimulate this development of the digestive tract. Gavage tube feeding is the common method for providing nutrition to very preterm infants. This procedure is used with these infants until they develop the necessary suck/swallow coordination needed to safely feed by mouth. Across NICUs, bolus gavage feedings are provided either by gravity or by the use of an intravenous infusion pump. Ideally in clinical practice, these feedings are infused over a prescribed amount of time (for example, 20 minutes). For those feedings that rely on gravitational flow, there may be factors present that interfere with rate of flow of formula or breast milk, such as diameter and material of the feeding tube, consistency of the formula, and height of feeding above the stomach. Therefore, the time taken to complete a feeding would be significantly increased, thereby decreasing efficiency. An important question to consider is whether inconsistent flow rates interfere with or impact maturation of the GI tract. The purpose of our study is to examine simulated flow rates across a variety of feeding tube diameters and materials, formula consistencies (including breast milk), and feeding heights. The following research questions will be addressed:

1) Are there differences in flow rates across tube diameters?
2) Are there differences in flow rates across tube materials?
3) Are there differences in flow rates across formula consistencies?

4) Are there differences in flow rates across feeding heights?

5) What other factors appear to be affecting flow rate?

6) Are flow rates consistent between each repeated trial?

Background

In 2007, more than 540,000 infants were born preterm. Of those, 86,523 were born very preterm (March of Dimes, 2009). Because of improvements in neonatal care and development of clinical standards, increasing numbers of these infants are surviving (Fanaroff, 2007). Therefore, a significant number of very preterm infants undergo gavage feeding. Approximately 50-65% of very preterm infants experience feeding intolerance (Boo, Soon, & Lye, 2000; McClure & Newell, 2000). Because of the need to stimulate the infant's GI system maturation and the fact that feeding intolerance is so prevalent, enteral feedings provided for these very preterm infants emerge as an exceptionally significant issue.

Minimal enteral nutrition, the provision of nutritionally insignificant volumes of enteral intake, is provided to stimulate the maturation of the GI tract, and is initiated during the first week of life. This minimal nutrition starts at approximately 10-20mL/kg/day, and eventually these feedings are advanced to full feedings, 120mL/kg/day. There must be significant physiologic adaptation and maturation of the GI tract before these full enteral feedings are safely achieved. Initiating minimal enteral nutrition has been proven to provide the infant with several benefits, including increased secretion of GI hormones and enzymes (Berseth, 1992; McClure & Newell, 2002; Shulman & Kanarek, 1993), and enhanced GI motility (Berseth & Nordyke, 1993), leading to improved tolerance of enteral feedings (Schanler, Shulman, Lau, Smith, & Heitkemper, 1999).

Though there is no current consensus regarding a distinct advantage of bolus gavage feedings over continuous feedings, many theorize that bolus feedings are a better method for providing enteral nutrition. Bolus feedings are thought to be physiologically more realistic because they force the gut to mimic the cyclical surges of hormone release normally seen in healthy term infants (Aynsley-Green, 1982, Aynsley-Green 1990). Furthermore, bolus feedings have been associated with significantly less feeding intolerance and more rapid weight gain than a continuous method (Schnaler, Shulman, Lou, Smith, & Heitkemper, 1999). A 2009 survey found that over 80% of physician and neonatal dietitian respondents prescribed intermittent bolus feedings for low birth weight infants in all weight groups (Hans, Pylipow, Long, Thureen, Georgieff, 2009).

As technological improvements continue allowing very preterm infants to survive at increasingly lower birth weights and gestational ages, it is necessary that we provide the adequate equipment necessary for their care. As the birth weights of these infants decrease, so does their esophageal diameter. This requires us to provide smaller diameter gavage feeding tubes. Currently in the NICU, gavage feeding tubes available for use with preterm infants range in size from 3.5Fr to 10Fr. While it may seem intuitive that smaller infants require tubes in smaller diameter, the timing and efficiency of gravity feedings using these smaller tubes has never been documented, nor have current practices.

Chapter III: Methodology

In this experimental laboratory study, four variables were studied: tube size, tube material, feeding type, and feeding height. Three trials were run for each possible combination of the variables, with some exceptions related to relevance. Three sizes of feeding tubes (3.5Fr, 5Fr, and 6.5Fr), as well as six feeding types at room temperature (Similac Special Care 20, Similac Special Care 24, Similac Neosure 22, Similac Alimentum 20, plain human breast milk, and human breast milk with 24 calorie fortifier) were studied. These tube sizes and feeding types were chosen based on typical use in the clinical setting for very premature infants. Additionally, each tube size was available in both materials of interest: silicone and polyurethane. Two different heights (7 inches and 12 inches) were also chosen to be studied. These heights were chosen based on common feeding heights in the clinical setting, determined by whether the nurse chooses to hang the feeding inside or outside of the infant's isolette. 30 mL of feeding was run for each trial. This amount is based on a normal bolus feeding amount in the clinical setting. All trials were to run by gravity.

Three work stations were set up for three researchers who had been trained in basic tube feeding technique to ensure uniformity in results. This included tube positioning as well as when to start and stop timing each feeding. Each researcher was provided with a stopwatch and reported resulting feeding times in minutes and seconds.

Each researcher was assigned one feeding type at a time. Researchers ran the polyurethane and silicone feedings side by side for each tube size (beginning with the largest size -6.5Fr- first) and at each height for visual comparison. Researchers started the stop watch once the tube was completely primed (to simulate actual time that an infant would be receiving nutrition) and stopped the stopwatch when the gravity was no longer effective and the feeding stopped infusing, which typically occurred when the last of the feeding was midway through the tube. Once the feeding had concluded and data were reported, each researcher rinsed their syringe and tube with clean water before beginning a new trial. Tubes were rinsed and reused between trials of the same feeding type, but not between trials of different feeding types. 90mL-120mL of each formula was available and formulas were also reused within a one day span (i.e. formulas that had been opened before the day trials were run was not used so as to avoid the risk of using spoiled formula, which changes in composition). The breast milk was also reused in a one day span but, as has been a timeless concern with breast milk, the fats and lipids separate much more quickly than with formula, and so breast milk trials were suspended once the breast milk had separated too much and continued a separate day. Because Similac Alimentum 20 is a pre-digested formula and has a significantly different composition from other formulas, the researchers noted that even the fastest possible trial (a large bore polyurethane tube run at 12 inches) still resulted in a flow rate that was too long to be considered and effective feeding for an infant. Therefore, the researchers chose not to continue running Similac Alimentum trials in smaller bore tubes, as any resulting data would not be useful. Similar decisions were made for findings with the smallest bore tube (3.5Fr). Once all final results were collected, they were analyzed with descriptive and inferential statistics.

One limitation this study faced was limited availability of supplies. Most NICUs would most likely use a new feeding tube every time the infant receives a gavage feeding. However, due to budget constraints, researchers were forced to rinse and reuse tubes when studying the same feeding type.

Chapter IV: Research results

Results

Results showed definite relationships between flow rate and tube size, tube material, feeding type, and height of feeding. Also identified were consistent results across flow rate trials.

Feeding type

Flow rates were variable across feeding types but consistent for each type of feeding. Increases in the feeding time for Similac Special Care 24 as compared to Similac Special Care 20 show that as calorie content rises, feedings require more time. Similac Neosure 22, which is has higher protein and carbohydrate counts, took more time as well. Regular human breast milk, which has no added fats or carbohydrates, had the fastest flow rate. Human breast milk with fortifier (resulting in 24 calorie breast milk) also had a much faster flow rate, second only to regular breast milk. This emphasizes that the type of fats and carbohydrates in the formulas increases feeding time, as well as the fact that increased calorie content results in increased feeding time.

Tube size

Results have shown that as tube sizes increase and become larger, feeding times decrease. Invariably, using a 6 Fr tube without changing any other conditions will result in a faster feeding time than using a 5 Fr tube. However, as will be discussed, using a silicone or polyurethane tube may have stronger implications than the bore of the tube.

Tube material

Results show a strong difference in flow rates between polyurethane and silicone tubes. Because of the wider internal diameter, the use of a polyurethane tube results in a much faster feeding time. This trend can be identified across all other variables (i.e. polyurethane flows faster than silicone among the same tube size, feeding type, and feeding height), and is even somewhat independent of tube size, as a feeding using a 5 Fr polyurethane tube will flow faster than one using a 6.5 Fr silicone tube. With all other factors controlled, the use of a polyurethane tube results in a feeding rate that is approximate 4x as fast as that resulting from the use of a silicone tube.

Feeding height

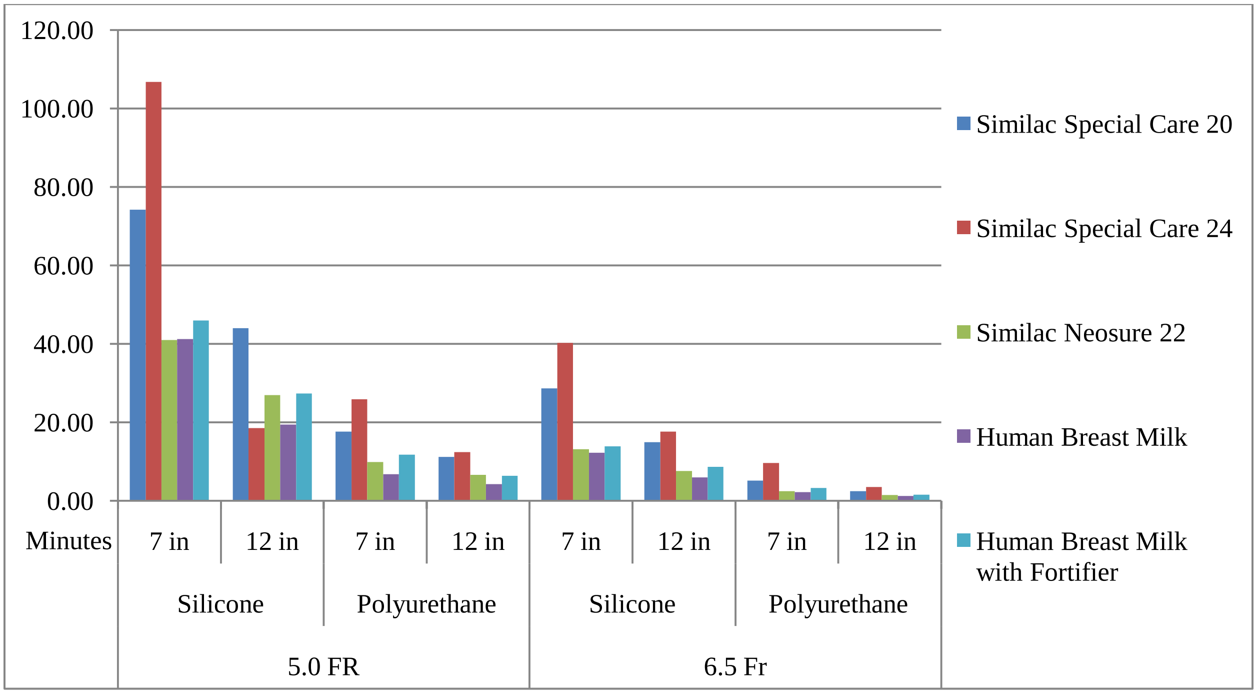
Because increasing the feeding height will in turn increase the force of gravity, as the height of feeding is increased, feedings flow at a faster pace.

Table 10-1: Mean flow rates in minutes with standard deviations

	5.0 FR			
	Silicone		Polyurethane	
	7 in	12 in	7 in	12 in
Similac Special Care 20	74.2 ± 1.80	44.01 ± 0.63	17.63 ± 0.47	11.17 ± 0.14
Similac Special Care 24	106.76 ± 8.55	18.57 ± 0.40	25.9 ± 2.21	12.44 ± 0.15
Similac Neosure 22	40.97 ± 1.10	26.93 ± 1.06	9.88± 0.41	6.63 ± 0.34
HBM	41.25 ± 1.89	19.44 ± 0.62	6.75 ± 0.45	4.29 ± 0.15
HBM with Fortifier	45.93 ± 1.41	27.34 ± 0.86	11.73 ± 1.07	6.41 ± 0.06

	6.5 Fr			
	Silicone		Polyurethane	
	7 in	12 in	7 in	12 in
Similac Special Care 20	28.69 ± 1.67	14.94 ± 0.61	5.18 ± 0.09	2.48 ± 0.06
Similac Special Care 24	40.29 ± 1.93	17.65 ± 0.34	9.65 ± 0.39	3.49 ± 0.06
Similac Neosure 22	13.18 ± 0.45	7.64 ± 0.36	2.5 ± 0.05	1.48 ± 0.09
HBM	12.23 ± 2.35	5.95 ± 0.36	2.23 ± 0.14	1.22 ± 0.02
HBM with Fortifier	13.88 ± 0.48	8.7 ± 0.61	3.25 ± 0.20	1.54 ± 0.03

Figure 11-1: Mean Gravitational Flow Rates



Chapter V: Conclusion

This study has demonstrated that there are several significant factors in the flow rate of gavage feedings given to very preterm infants. The fastest feeding was attained by using a 6 Fr polyurethane tube with regular breast milk at 12 inches. This feeding flowed in less than two minutes, while the slowest feeding, using a 5 Fr silicone tube with Similac Special Care 24 at 7 inches, took nearly two hours. Both of these feeding times are of concern. A bolus 30 mL feeding given to a neonate in less than two minutes is likely to cause intense discomfort to the infant, distend the stomach, and possibly lead to feeding intolerance, a significant issue in very preterm infants. Conversely, a feeding that takes hours is concerning as well. Not only is the purpose of the bolus feeding effectually negated, but there is also the potential of overfeeding the infant. Most infants are fed about every 3 to 4 hours, and if the feeding itself takes several hours, it is likely that the infant is being fed a new feeding before it has had any opportunity to digest the previous feeding. There are also nutrient attainment and growth concerns.

The comparison of variables shows which ones play the most important roles in affecting the feeding rate. The height of the feeding is related the flow rate as an increased feeding height results in a less timely feeding. The same is true for tube size; a larger bore results in a faster feeding. Furthermore, feeding type plays a significant role in the feeding rate. Increased calories increase feed time, as well as increased nutrient (lipids, carbohydrates, and proteins) content. The most significant finding of this study, however, was the difference between silicone and polyurethane feeding tubes. Because of the increased strength and therefore increased internal diameter of the polyurethane tubes, polyurethane feedings flowed up to four times as fast as those using silicone tubes. This fact has several profound implications. When preparing to feed an infant, the knowledge of the effects of using silicone and polyurethane would be extremely beneficial. When dealing with a more calorically and/or nutritionally dense feeding (such as Similac Special Care 24), or a smaller tube, the practitioner could use polyurethane tubing so as to quicken what is likely to be a timely feeding. Similarly, when preparing to feed with a "thinner" feeding (such as regular breast milk) or a larger tube, the practitioner could choose a silicone tube so as to slow what would otherwise be a very rapid feeding. This fact also gives rise to a further question concerning fluid aspiration. Aspirating fluids from the stomach is a common method of determining both tube placement and residuals in neonates (Eisenberg, Metheny, and McSweeney, 1989), and the difference in tube material may result in the inability to withdraw fluids from the stomach. The nurse would most likely mistake the lack of aspirate to mean either tube misplacement or an empty stomach, which again could result in discomfort for the infant and overfeeding. Most concerning about this difference between silicone and polyurethane tubing is the fact that few NG/OG tubes are available in both materials, and astoundingly, few are even labeled by material. Most manufacturers and hospitals the researchers contacted while obtaining supplies did not differentiate in their supply by material. This clearly shows that there is a lack of knowledge and understanding of the implications of this variable among manufacturers, supply coordinators, and clinicians.

Recommendations for the future include further research, increased education and policy development. It is of extreme importance that both advanced practice clinicians who are writing orders and nurses who are carrying them out understand the implications of all feeding variables on flow rates, particularly those of silicone vs. polyurethane tubing. Equally as important, it is necessary to continue research on this subject. Trials should be conducted that determine what variables can be manipulated in order to obtain satisfactory feeding times across all factors. Additional studies should focus on the ability to aspirate fluids from feeding tubes with consideration given to tube size and material, as well as feeding type. Furthermore, efforts should be focused on the development of a feeding delivery system that does not rely solely on gravity for those feedings with rates that cannot be effectively controlled by manipulating other variables. Finally, the results of these efforts should be used to develop and publish national standards and protocols for delivering feedings to very preterm infants.

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